Treatment for peripheral arterial obstructive disease: An appraisal of the economic outcome of complications

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Objective: **This study determined the average estimated total costs after treatment for peripheral arterial occlusive disease (PAOD) and evaluated the effect of postoperative complications and their consequences for the total costs.**

Methods: **Cost data on all admissions involving treatment for PAOD from January 2007 until July 2007 were collected. A prospective analysis was made using the patient-related risk factor and comorbidity (Society for Vascular Surgery/International Society of Cardiovascular Surgeons) classification, primary and secondary treatment, and prospectively registered complications. At admission, patients without complications were placed in group A, and those with complications were in group B. Prospectively registered complications were divided into patient management (I), surgical technique (II), patient's disease (III), and outside surgical department (IV). The consequences of these were divided into minor complication, no long-term consequence (1A), additional medication or transfusion (1B), surgical reoperation (2A), prolonged hospital stay (2B), irreversible physical damage (3), and death (4). The main outcome measures were total costs of patients and costs per patient (PP), with or without the presence of complications, cost of complications and costs per complication (PC), and the costs of their consequences calculated in euros (€).**

Results: **Ninety patients (mean age, 71.4 years; 59% men) were included. Group B patients had a significantly higher American Society of Anesthesiologists (4) and Fontaine (3) classification and more secondary procedures. Total costs were €1,716,852: group A, €512,811 (PP €12,820); and group B, €1,204,042 (PP €24,081). The costs of the 115 complications were €568,500 (PC €4943). Split by the cause of the complication, costs were I, €95,924 (PC €2998); II, €163,137 (PC €8157); III, €289,578 (PC €5171); and IV, €19,861 (PC €2837). The increase of costs in group B was mainly caused by additional medication or transfusion (1B) €348,293 (61.3%), a surgical reoperation (2A) €118,054 (20.8%), or prolonged hospital stay (2B) €60,451 (10.6%). Patients who died caused 23% of the total costs.**

Conclusion: **Complications cause an increase of the average estimated total costs in the treatment for peripheral arterial occlusive disease and are responsible for 33% of these total costs. The most expensive complications were errors in surgical technique and patient's disease, resulting in surgical reoperation or additional medication, or both, or transfusion, the two most expensive consequences. (J Vasc Surg 2008;48:368-76.)**

In today's society, cost containment is a goal that extends into the health care sector. Rising health care costs represent a critical issue that is important in decision making. Insurance organizations are playing an increasingly important role in the delivery of health care and will not permit patients to be admitted to medical centers that cannot deliver health care at lower costs than competing hospitals. Medical specialists, in particular, are under significant pressure to decrease expenses and eliminate unnecessary costs by optimizing resource use.

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The incidence of peripheral arterial occlusive disease (PAOD) in Western societies is increasing due to an overall increase of cardiovascular disease, diabetes mellitus, hypertension, and obesity.[1-5] This increased incidence of PAOD directly results in increased overall health care-related costs as well as specific treatment-related costs. The treatment-related costs of PAOD vary, ranging from minimal costs for conservative therapy to maximal costs for repetitive surgical interventions. Especially postinterventional complications, such as redo bypass surgery, result in prolonged hospital admission and reoperation procedures, ultimately leading to increased health care costs.[6-8]

In general, the treatment aim is to ensure that the patient has a clinically optimal solution with long-term benefits in an acceptable economic frame. In times of restricted health care budgets, a detailed insight into the costs related to treatment of specific diseases such as PAOD is essential to constrain unlimited health care expenses and to implement measurements to reduce health care costs. Whatever reimbursement system is used, if one wants to investigate cost-effectiveness of treatment modalities from a hospital perspective, the actual cost is the preferred value to analyze.[9,10]

Table I. Baseline characteristics, classified according to the SVS/ISCVS standards,[11,12] of the 90 patients stratified by absence (group A) or presence (group B) of complications

Characteristic[b]	*Total*	*Group A*	*Group B*	P
Patients, No.	90	40	50	
Gender				.848
Male	53 (59)	24 (60)	29 (58)	
Female	37 (41)	16 (40)	21 (42)	
Age, years				.269
Mean (SD)	71.4 (13.3)	67.4 (13.1)	74.6 (12.7)	
Range	46-93	36-88	39-93	
Fontaine classification				<.001
2b	12 (13)	12 (30)	7 (0)	
3	25 (28)	15 (38)	10 (20)	
4	53 (59)	13 (33)	40 (80)	
ASA classification[14]				<.001
2	41 (46)	27 (68)	14 (28)	
3	43 (48)	13 (33)	30 (60)	
4	6 (7)	0 (0)	6 (12)	
Comorbidity (SVS-ISCVS)				
Cardiac disease	53 (59)	15 (38)	38 (76)	<.001
Pulmonary disease	21 (23)	10 (25)	11 (22)	.738
Renal disease	11 (12)	1 (3)	10 (20)	.012
Carotid disease	14 (16)	2 (5)	12 (24)	.013
Diabetes mellitus	31 (34)	13 (33)	18 (36)	.728
Hyperlipidemia	21 (23)	10 (25)	11 (22)	.738
Hypertension	48 (53)	19 (48)	29 (58)	.321
Tobacco use	29 (32)	15 (38)	14 (28)	.338

ASA, American Society of Anesthesiologists; *SD,* standard deviation; *SVS-ISCVS,* Society of Vascular Surgery/North American Chapter, International Society of Cardiovascular Surgery.
[a]Data are presented as number (%), unless otherwise specified.

Many cost-identification analyses of treatment of PAOD have focused on the intervention itself.[9,10] Treatment cost of PAOD can be divided by primary treatment expenses and secondary costs due to postprocedural complications. These complication-related costs are frequently caused by wound care management, prolonged lengths of stay in the intensive care unit (ICU) and the hospital, and reoperations. To our knowledge, a specific detailed analysis of complication-related cost of treatment of PAOD has not been published.

The goal of this study was to perform a detailed cost-evaluation of patients admitted and treated for PAOD. This analysis assessed the actual costs of primary treatment, including preoperative work-up and primary intervention; furthermore, complication-related costs were identified. Causes and consequences of complications were also registered and related expenses assessed.

METHODS

Patients. A 6-month survey was performed on 90 consecutive patients admitted and treated for PAOD from January 2007 until July 2007. Criteria for inclusion in the study population were intermittent claudication (IC) or critical lower limb ischemia (CLI). IC was defined as extremity pain, discomfort, or weakness that is consistently produced by the same amount of walking or equivalent muscular activity in a given patient and that is promptly relieved by cessation of that activity, with a pain-free walking distance <100 m and an ankle pressure (AP) after exercise of <50 mm HG (Fontaine stage 2b). This corresponds with category 3 of the Society of Vascular Surgery/North American Chapter of the International Society for Cardiovascular Surgery (SVS/ISCVS) standards.[11,12] CLI was defined as ischemic rest pain (Fontaine 3) with a resting AP of <40 mm HG, and gangrene or nonhealing ischemic ulceration (Fontaine 4) with a resting AP of <60 mm HG. This corresponds with categories 4, 5, and 6 of the SVS/ISCVS. At admission, patients without complications were placed in group A and those with complications in group B. This adjustment of the two groups allowed a meaningful comparison of costs related to complications.

Risk factors and comorbidities. Risk factors and comorbidities were registered prospectively for all patients during their admission intake. Smoking, hypertension, cardiac disease, hyperlipidemia, diabetes mellitus, renal disease, pulmonary disease, carotid disease, and age were classified according to the SVS/ISCVS standards.[11,12] The risk factor and comorbidity management was conducted by a vascular specialist or cardiologist preoperatively in the outpatient clinic or during admission, before operation, when urgent intervention was indicated. The American Society of Anesthesiologists (ASA) classification[13] of patients was prospectively determined according to their general preoperative condition. Data for the risk factors and comorbidities are listed in Table I.

Treatment of PAOD. Treatment was divided in nonsurgical, endovascular, and surgical (vascular and nonvascular) treatment. The nonsurgical treatment in our study

Table II. Costs after treatment for peripheral arterial occlusive disease by group and subanalysis of patients who died

Appraisal of costs[a]	*Total (€)*	*Group A (€)*	*Group B (€)*	*Patients who died (€)*
Primary treatment	568,570	251,292	317,278	123,180
Pre-op workup	128,739	56,439	72,300	29,022
Non-surgical	2381	1191	1191	1191
Endovascular	217,643	94,183	123,460	62,403
Surgical	219,807	99,480	120,328	30,564
After primary treatment	1,148,282	261,518	886,763	274,626
Pharmacy	12,530	. . .	12,530	1815
Admission	1,034,511	254,400	780,111	243,200
Laboratory services	24,238	3543	20,695	6001
Imaging	8961	1025	7937	4868
Consulting specialists	14,609	2550	12,059	3897
Procedures[b]	53,432	. . .	53,432	14,843
Total				
Costs	1,716,852	512,811	1,204,042	397,807
Percentage, %	NA	29.9	70.1	23
Per patient	19,076	12,820	24,081	24,862

Group A, Patients without complications; *Group B*, patients with complications; *NA*, not applicable.
[a]Data are presented as euros (€), unless otherwise specified.
[b]Surgical and endovascular.

indicates all treatment strategies outside the operating room, including local pain or wound management, antibiotic therapy, and superficial necrosectomy performed on the ward and not in the operating room.

Endovascular treatment reflected urokinase treatment[14-17] and percutaneous transluminal angioplasty (PTA). The technique of thrombolysis used and the doses of urokinase administered were at the discretion of the interventional radiologist. PTA was done with conventional balloon dilatation of the lesion, with or without stent placement. The vascular surgical treatment consisted of thrombectomy, endarterectomy, or a bypass graft procedure. Bypass grafting was performed according to standard vascular techniques, using preferably reversed vein for infrainguinal femoropopliteal, crural, or pedal bypass procedures, and Dacron or polytetrafluoroethylene (PTFE) for aortofemoral and femorofemoral bypass grafting. All these vascular operations were performed by or under the supervision of a vascular surgeon.

The nonvascular surgical treatment consisted of drainage/débridement, a minor amputation, defined as toe or transmetatarsal amputation, or a major amputation, defined as an amputation above or below the level of the knee.

Complications: causes and consequences. The following general definition of a complication developed by the Association of Surgeons of the Netherlands (ASN)[18-20] was used: a complication is a condition or event, unfavorable to the patient's health or treatment, causing unintentional damage or requiring a change in therapeutic policy or additional treatment, which arose during admission or ≤30 days after discharge. A patient admitted with gangrenous toes, who then required amputation after a successful limb-saving vascular reconstruction, was not considered as a complication. However, gangrenous toes were considered a complication if they developed during the hospital stay after vascular reconstruction and ultimately required amputation.

All interventions performed during the hospital stay that were unforeseen at the time of admission were considered complications and calculated as such. In this complication registration system, the most severe complication was coded. For instance, if a patient had a myocardial infarction and recovered, then of course, this was coded as a myocardial infarction, but if a patient died from a myocardial infarction, this was coded as death. Thus, the most invasive or most severe consequence of each complication was coded. This way of classification enabled us to evaluate the most severe adverse events in our practice.

In brief, a complication is identified by one of the physicians in our surgical team who documents the complication in an electronic medical file real-time. This file is operational throughout the hospital and the outpatient clinic, which makes recording easy. In-hospital documented complications are automatically presented at the daily surgical conference in the morning and the afternoon. All causes of the complications and their consequences were coded weekly according to our complication registration system[21,22] as listed in the protocol outlined in Appendix I (online only). All senior surgeons, residents, and interns joined this weekly meeting.

Appraisal of costs. To determine the economic effect of health care services on the budget, estimates of actual economic costs are required to represent the value of the resources used. As listed in Appendix II (online only),[23-25] cost data were obtained from several hospital accounting databases. As listed in Table II and Appendix II, total hospital costs were divided by "primary treatment" and costs "after primary treatment."

As listed in Appendix II, costs of the primary treatment included the costs of the preoperative workup and standard initial care (nonsurgical, endovascular, or surgical). For example, patients with gangrenous toes at the time of admission who underwent successful limb-saving vascular reconstruction, followed by toe amputation, were not con-

sidered complications because the toes were already gangrenous at admission and all costs were primary treatment-related costs.

The costs after primary treatment included the costs of additional medication or transfusion (antibiotics, neurology, cardiac, and blood bank), the total length of stay (defined as the number of days from date of admission to date of discharge), clinical laboratory services (hematology, microbiology, and chemistry), imaging (x-ray, ultrasound, computed tomography scan, duplex ultrasound imaging, and electrocardiography), consulting specialist, and secondary surgery. For example, if a patient developed gangrenous toes during admission after vascular reconstruction, ultimately leading to amputation, this was considered a complication (as defined by our complication registration system), and all costs related to this amputation were costs after primary treatment. Important to mention is that included in the costs of the primary treatment and after primary treatment were the fees of the various staffs, including duplex ultrasound technicians, laboratory, hematology/microbiology laboratory, and angiography; consultants (internal medicine, cardiology, and neurologist), radiologists, anesthesiologists, operating room staff, and the vascular surgeon. All costs in this article were calculated in 2007 euros (€) and were defined as average estimated total costs.

Registration and statistical analysis. An Access database (Microsoft Corp, Bellingham, Wash) was used to enter patient information for a specifically designed computerized analysis program for vascular patients. Statistical analyses were performed through a computerized software package, using Excel (Microsoft) and SPSS 12.01 software (SPSS Inc, Chicago, Ill). The Fisher exact test, Student *t* test, or χ^2 test were used to assess differences between both groups for a given parameter. The secondary procedures were analyzed with the Mann-Whitney *U* test. For all statistical analyses, a value of $P < .05$ was considered to be statistically significant.

RESULTS

Patients. Fifty-three men (59%) and 37 women (41%) underwent treatment. Mean age was 71.4 years (range, 36-93 years). Indication for treatment of PAOD was Fontaine 2b in 12 patients (13%), Fontaine 3 in 25 (28%) and Fontaine 4 in 53 (59%). Mean duration of admission was 14 days (range, 1-80 days). The 30-day postoperative mortality rate was 13%. Patients' characteristics in terms of sex, age, Fontaine and ASA classification, and comorbidity are listed in Table I.

Risk factors and comorbidity. No sex or age differences were found between the groups as listed in Table I. Patients in group B had a significantly higher Fontaine classification and also had a significantly higher ASA classification for cardiac disease ($P < .001$), renal disease ($P = .012$), and carotid disease ($P = .013$). No differences were found between the groups for pulmonary disease ($P = .738$), diabetes mellitus ($P = .728$), hyperlipidemia ($P = .738$), hypertension ($P = .321$), and tobacco use ($P = .338$).

Table III. Therapy at admission of the 90 study patients and stratified by absence (group A) or presence (group B) of complications

Treatment[a]	*Total*	*Group A*	*Group B*	P
Primary treatment	90 (100)	40 (44)	50 (56)	.817
Nonsurgical				
Wound, pain treatment	6 (7)	3 (8)	3 (6)	
Endovascular				
Urokinase	13 (14)	5 (13)	8 (16)	
PTA + stent	19 (21)	10 (25)	9 (18)	
Surgical				
Vascular				
Thrombectomy	3 (3)	1 (3)	2 (4)	
Endarterectomy + patch	8 (9)	4 (10)	4 (8)	
Bypass graft	26 (29)	14 (35)	12 (24)	
Nonvascular				
Drainage/débridement	1 (1)	0 (0)	1 (2)	
Minor amputation	5 (6)	3 (8)	2 (4)	
Major amputation	9 (10)	0 (0)	9 (18)	
Secondary treatment	13 (100)	0 (0)	13 (100)	<.001
Endovascular				
PTA + stent	2 (15)	0 (0)	2 (15)	
Surgical				
Vascular				
Thrombectomy	1 (8)	0 (0)	1 (8)	
Endarterectomy + patch	3 (23)	0 (0)	3 (23)	
Bypass graft	1 (8)	0 (0)	1 (8)	
Nonvascular				
Drainage/débridement	4 (31)	0 (0)	4 (31)	
Major amputation	2 (15)	0 (0)	2 (15)	

PTA, Percutaneous transluminal angioplasty.
[a]Data are presented as number (%).

Treatment. As listed in Table III, no differences were found between the groups for primary treatment: six nonsurgical (7%, n = 6), endovascular (35%, n = 32) and surgical (58%, n = 52). As listed in Tables IV and V, 115 complications were registered from the time of admission among the entire group of 90 patients during the 30-day postoperative period. Compared with the patients in group A, those in group B underwent significantly more secondary treatment ($P < .001$) because of postoperative complications.

Patients without complications. As listed in Table I, group A comprised 40 patients, 24 men (60%) and 16 women (40%), with a mean age of 67.4 years (range, 36-88 years) years. Indication for treatment of PAOD was Fontaine 2b in 12 patients (30%), Fontaine 3 in 15 (38%), and Fontaine 4 in 13 (33%); and 68% were classified as ASA 2. Mean duration of admission was 7.4 days (range, 1-17 days). Primary treatment consisted of nonsurgical treatment in three patients (8%), endovascular treatment in 15 (38%), and surgical treatment in 22 (56%).

Patients with complications. As listed in Table I, group B comprised 50 patients, 29 men (58%) and 21

Table IV. Complications in the 90 patients after treatment for peripheral arterial occlusive disease

Complication (cause)	*No. (%)*
Total complications	115
Shortcomings in patient management	32 (28)
Shortcomings in medication	4 (3)
Blister	4 (3)
Cardiac failure	3 (3)
Renal failure	7 (6)
Other	14 (12)
Shortcomings in surgical technique	20 (17)
Hemorrhage	3 (3)
Abscess	1 (1)
Wound infection	6 (5)
Wound dehiscence	2 (2)
Wound hematoma	2 (2)
Bypass graft procedure	
Infection	1 (1)
Occlusion	4 (3)
Thrombosis	1 (1)
Patient's disease	56 (49)
Cardiac failure	16 (14)
Pulmonary failure	5 (4)
Renal failure	3 (3)
Death	16 (14)
Other	16 (14)
Outside surgical department	7 (6)
Hemorrhage	4 (3)
Wound infection	1 (1)
Bypass graft occlusion	1 (1)
Cardiac failure	1 (1)

women (42%), with a mean age of 74.6 years (range, 39-93 years). Indication for treatment of PAOD was Fontaine 3 in 10 patients (20%) and Fontaine 4 in 40 (80%), and 60% were classified ASA 3. Primary treatment consisted of conservative treatment in three patients (6%), endovascular treatment in 17 (34%), and surgical treatment in 30 (60%). A total of 13 secondary procedures (2 endovascular, 5 vascular, 6 nonvascular treatments) were the consequences of 115 postoperative complications during the 30-day postoperative period (Tables III and IV). The mean duration of admission was 19.5 days (range, 5-80 days).

As listed in Table VI, 16 patients (17.7%) died during admission, and 12 (13%) died ≤30 days postoperatively. Mean age was 82 years (range, 61-93 years). Indication for treatment of PAOD was Fontaine 3 in three patients (19%) and Fontaine 4 in 13 (81%), and 81% were classified as ASA 3 and 13% as ASA 4. The primary treatment was nonsurgical in six patients (38%), endovascular in two (12%), and surgical in 8 (50%). Mean duration of admission was 19 days (range, 5-53 days).

Complications: causes and consequences. As listed in Tables IV and V, 115 complications were registered. Shortcomings in patient management (group I) reflected 28% of all complications, of which, 47% resulted in additional medication or transfusion, 25% were minor with no long-term consequence, and 22% resulted in a prolonged hospital stay. Shortcomings in surgical technique (group II) reflected 17% of all complications, of which 45% resulted in a surgical reoperation, 30% resulted in additional medication or transfusion, and 20% were minor complications with no long-term consequence. Complications related to the patient's disease (group III) reflected 49% of all complications, of which 54% resulted in additional medication or transfusion and 29% resulted in the most severe consequence, early death. Complications that occurred outside the surgical department (group IV) reflected 6% of all complications, of which 43% resulted in a prolonged hospital stay and 29% resulted in additional medication or transfusion.

In total, additional medication or transfusion was the consequence of 46% of all consequences, mainly caused by complications related to the patient's disease (group III) and shortcomings in patient management. Prolonged hospital stay (14%) was mainly caused by shortcomings in patient management. A surgical reoperation occurred in 12% of all consequences and was mainly caused by a shortcoming in surgical technique (group II).

The 16 patients who died sustained 49 complications (43%), including the complication of death itself (Table VI). Shortcomings in patient management (group I) reflected 18% of these complications, shortcomings in surgical technique (group II) reflected 14%, and complications related to the patient's disease (group III) reflected 67%.

Appraisal of costs. As listed in Table VII, the Fontaine 4 patients were responsible for 70.2% (€1,203,459) of the total costs; they were two times more expensive compared with the Fontaine 2b patients. According to the ASA classification, ASA 3 patients were responsible for 48.4% (€830,555) of the total costs; however, the ASA 4 patients were two times more expensive compared with the ASA 2 patients.

The costs of the treatment for PAOD of the 90 patients were €1,716,852 during the study period (Table II). The complication group consumed 70.1% of this amount, resulting in a difference of €691,231 in total costs and in costs per patient of €11,261 between both groups. The primary treatment (€317,278), admission days (€780,111), and secondary procedures (€53,432) were main drivers of the costs in the complication group.

For the patients without complications, the two main costs were primary treatment (€251,292) and admission days (€254,400). There was no difference in the costs per patient for primary treatment comparing group A (€6282) with group B (€6346). However, a difference of €11,197 was seen in case of the costs per patient after primary surgery between group A (€6538) and group B (€17,735). The mean length of admission in group B of 19.5 days ($P <$ .068) caused a difference of €9242 in costs of the length of stay in the hospital.

As listed in Table VII, the 115 complications caused costs after treatment for PAOD of €568,500; they consumed 33.1% of the total costs, with costs per complication of €4943.

A shortcoming in surgical technique (group II) was the most expensive complication, consuming 28.7% of the total complication costs with complication costs of €8157. This

Table V. Complications (causes and consequences) after treatment for peripheral arterial occlusive disease of the total sample ($n = 115$)

Complication causes	*Consequence, No. (%)*[a]						
	Total	*1A*	*1B*	*2A*	*2B*	*3*	*4*
Shortcomings							
In patient management	32 (28)	8 (25)	15 (47)	1 (3)	7 (22)	1 (3)	0 (0)
Surgical technique	20 (17)	4 (20)	6 (30)	9 (45)	1 (5)	0 (0)	0 (0)
Patient's disease	56 (49)	1 (2)	30 (54)	2 (4)	5 (9)	2 (4)	16 (29)
Outside surgical dept	7 (6)	1 (14)	2 (29)	1 (14)	3 (43)	0 (0)	0 (0)
Total	115 (100)	14 (12)	53 (46)	13 (12)	16 (14)	3 (3)	16 (14)

[a] *1A,* Minor complication, no long-term consequence; *1B,* additional medication or transfusion; *2A,* surgical reoperation; *2B,* prolonged hospital stay; *3,* irreversible physical damage; *4,* death.

Table VI. Baseline characteristics of the 16 patients who died during the study period

Patient	*Sex; age (y)*	*Class*[a]	*LOS, days*	*Primary treatment*	*Complications*[b]	*Cause of death*
1	M; 90	A3; F4	11	Wound and pain treatment	None	Septicemia
2	M; 61	A3; F4	6	Urokinase	None	Cardiac failure
3	F; 85	A3; F4	15	Urokinase	None	Unknown
4	F; 80	A3; F4	7	Urokinase	Cardiogenic shock	Cardiac failure
5	F; 89	A3; F4	50	Urokinase	CHF, MI, feces culture, other neurology	Respiratory failure
6	M; 72	A3; F3	5	Urokinase	Wound hematoma	Septicemia
7	F; 93	A3; F3	7	Urokinase	Wound hematoma, other neurology	Cardiac failure
8	F; 89	A3; F3	19	PTA + stent	UTI, renal failure, electrolytes failure, decrease Hb, fracture	MOF
9	M, 80	A3; F3	7	Endarterectomy + patch	Thrombosis BGP, pneumonia, CHF	Respiratory failure
10	M; 76	A2; F4	53	Endarterectomy + patch	Abscess, feces culture	Unknown
11	F; 89	A3; F4	12	Bypass graft	Occlusion BGP feces culture	Unknown
12	M; 80	A3; F4	53	Bypass graft	Patient management, wound dehiscence pneumonia, AF, asystolic, other neurology	Cardiac failure
13	M; 77	A3; F4	30	Bypass graft	Hypotension, AF, other neurology	Respiratory failure
14	F; 86	A3; F4	6	Major amputation	None	MOF
15	M; 87	A4; F4	7	Major amputation	CHF, renal failure	Cardiac failure
16	M; 83	A4; F4	16	Major amputation	Wound dehiscence, feces culture	Unknown

AF, Atrium flutter; *BGP,* bypass graft procedure; *CHF,* congestive heart failure; *Hb,* hemoglobin; *LOS,* length of stay; *MI,* myocardial infarction; *MOF,* multiorgan failure; *PTA,* percutaneous transluminal angioplasty; *UTI,* urinary tract infection.
[a]According to the American Society of Anesthesiologists *(A)*[13] and the Fontaine classification *(F).*
[b]Important to stress is that the complication "death" is not included in the Complications.

amount was primarily caused by costs of admission days (€5961) and secondary surgery (€1882). The complications cost of patient's disease (group III) was €5171, amounting to 50.9% of the total complication cost, of which €4572 was mainly a result caused by mean costs of admission days. Shortcomings in patient management (group I) and complications outside the surgical department (group IV) represented the less expensive groups of complications, respectively €2998 and €2837 of complication costs.

The total costs of the consequences of the 115 complications were also evaluated, as listed in Tables II and VII. Surgical reoperation (group 2A) was the most expensive consequence; it consumed 20.8% of the total consequence costs, with a mean consequence cost of €9081. This amount was primary caused by costs of admission days (€4924) and secondary surgery (€3847). Additional medication or transfusion (group 1B) consumed 61.3% of the total consequence costs, with consequence costs of €6572, of which €6159 occurred from mean costs of admission days. Prolonged hospital stay (group 2B) only contributed 10.6% to the total consequence costs, with a mean consequence cost of €3778. The minor complication with no long-term consequence (group 1A), the irreversible physical damage (group 3), and death (group 4) represented the least expensive groups of consequences, with respectively costs of €2210, €2505, and €203.

The period before the actual occurrence of a patient's death reflects increased admission days ($n = 304$) because of the occurrence of 43% of all registered complications in these patients. As listed in Table II, the costs after primary treatment (€274,626) of these patients reflect 31% of the costs after primary treatment of all patients with complications (€886,763). The total costs of these 16 patients (€397,807) reflect 23% of the total costs (€1,716,852) of all 90 patients treated for PAOD in the study period.

Table VII. Costs divided by Fontaine classification, American Society of Anesthesiologists classification, and complications

Category	*No.*	*Total €*	*%*	*Per patient, €*
Diagnosis & comorbidity				
Fontaine classification				
2b	12	133,400	7.8	11,117
3	25	378,005	22	15,120
4	53	1,203,459	70.2	22,707
ASA classification[13]				
2	41	678,775	39.6	16,555
3	43	830,555	48.4	19,315
4	6	205,534	12	34,256
Complications				
Causes				
Group I	32	95,924	16.9	2998
Group II	20	163,137	28.7	8157
Group III	56	289,578	50.9	5171
Group IV	7	19,861	3.5	2837
Total	115	568,500	NA	4943
Consequences				
Group 1A	14	30,939	5.4	2210
Group 1B	53	348,293	61.3	6572
Group 2A	13	118,054	20.8	9081
Group 2B	16	60,451	10.6	3778
Group 3	3	7516	1.3	2505
Group 4	16	3248	0.6	203
Total	90	1,716,852	NA	19,076

ASA, American Society of Anesthesiologists; *NA,* not applicable; *Group I,* shortcomings in patient management; *Group II,* shortcomings in surgical technique; *Group III,* patient's disease; *Group IV,* outside surgical department; *Group 1A,* minor complication, no long-term consequence; *Group 1B,* additional medication or transfusion; *Group 2A,* reintervention by surgeon; *Group 2B,* prolonged hospital stay; *Group 3,* irreversible physical damage; *Group 4,* death.

DISCUSSION

The primary goal of this study was to provide insight in actual cost of treatment of PAOD in general and of additional cost of postprocedural complications. The secondary goal was to analyze costs related to specific causes and consequences of complications. Cost-efficiency of treatment of PAOD is important in today's world of financial constraints on health expenditure. Valid cost-estimates may help identify the optimal treatment strategy for patients with PAOD. Cost-accounting methods introduced in hospitals nationwide should improve cost-estimates substantially. The in-hospital financial burden of treating PAOD can be divided into the cost of primary treatment and the cost after primary treatment (Table II) and is considerable during admission. Of most concern in this respect is the excessive financial burden that each failed intervention procedure (either endovascular or surgical) can place on our vascular unit. The study population included all patients admitted and treated for PAOD during a defined period from a defined population and therefore provides a good insight in the economic consequences of PAOD treatment. We make several observations that advance this field of inquiry.

First, we found statistically significant differences of pretreatment symptoms (Fontaine classification) and comorbidity (ASA classification) between group A and B. Concerning the costs represented by the Fontaine and the ASA classifications, an elevating trend was observed in accordance with the classification. This could be explained by the fact that the patients (group B) classified Fontaine 4 or ASA 3 or 4, or both, have the highest form of PAOD and represent a high-comorbidity group of patients. Both result in the most expensive form of preoperative workup and a high incidence of postoperative complication-related costs. Fontaine 4 and ASA 4 patients were twice as expensive as Fontaine 2b and ASA 2 patients, respectively.

Second, no differences were found concerning the kind of primary treatment between group A and B resulting in approximately the same costs per patient in both groups (€6300). The overall costs of the primary treatment reflected 33% of the total costs.

Third, the results of our analyses indicate that considerable extra costs are incurred because of complications after treatment of PAOD, which increased the total costs per admission substantially. The overall costs of the complications reflected 33% of the total costs. The shortcoming in surgical technique (group II) was the most expensive cause of a complication, and the patient's disease (group III) consumed half of the total complication costs. A likely explanation for these high additional costs is that patients with complications need longer hospitalization (secondary procedures) and may require more additional care than other patients. Shortcomings in patient management (group I) and surgical complications (group II) are causes of complications that could be prevented by structured changes in perioperative management and surgical protocol; they are susceptible for improvement and thereby cost reduction. Prevention of the occurrence of these causes of complications would result in a significant reduction in costs, because they are responsible for 45.6% of the additional costs.

Fourth, patients in group B tended to undergo secondary treatment more frequently. If a secondary treatment was involved, a new workup, extra admission time, and the procedure itself added to the total costs. Costs associated with secondary treatment constituted 20.8% of the total costs of the consequences and reflected the most expensive consequence per complication (€9081). Additional medication or transfusions were responsible for 61.3% of the costs of all consequences.

Fifth, the consequence of death itself was not very expensive; however, the patients who died reflect a group that is responsible for 23% of the total costs of all patients. The period before the patient actually dies is a very expensive period because of the occurrence of 43% of all registered complications, automatically resulting in an increased admission period and therefore increasing total costs.

Sixth, as we realize, complications will always occur in every surgical department, and it is an illusion to strive for a practice without any complications. However, our goal is to strive for the highest possible quality of care with as few

as possible adverse events. We do realize that owing to extensive preoperative comorbid conditions, especially in our specific patient population, complications are inevitable. In this and in previous studies from our clinic,[21,22] however, we observed that shortcomings in patient management or in surgical technique caused a significant portion of all complications. Especially these two categories are human errors and, therefore, these complications are preventable. For instance, one of the most frequent registered complications caused by shortcomings in patient management was postoperative fluid overload ultimately leading to congestive heart failure and even myocardial infarction. After analyzing the cardiac adverse events that were caused by shortcomings in patient management, we altered the postoperative fluid protocol to prevent these adverse events.

The Dutch financial health care system is still developing its methods of cost calculations. In January 2006, a fairly rigid budget system, diagnosis treatment code (DTC),[23] was introduced to constrain hospital charges. In this system, a diagnosis is related to a standardized budget per year. For instance, health care insurance companies reimburse the combination of the diagnosis with its treatment. These DTC prices are negotiated between individual health care providers and health care insurance companies. In this DTC, the specific treatment ranging from conservative treatment to extensive surgical interventions is not predefined.

This study indicates that complication-related costs of the treatment of PAOD are strongly correlated with the ASA and Fontaine classifications. The recently implemented Dutch DTC system does not take into account the classifications for these preoperative patient-specific comorbidities and specific severity of disease. In a system in which health care providers receive standardized, up-front negotiated reimbursements independent of the patient case mix that is treated, health care physicians possibly tend to treat patients with minor comorbidities to reduce the incidence of postoperative complications and thereby costs.

This study is limited by its size of 90 patients, of which 40 patients were without complications and 50 patients had complications. A limitation of this study may be the restriction of data collection from only one hospital, which might not be completely representative for all hospitals. Also the sample was composed exclusively of patients with PAOD; therefore, these financial results may not generalize to other vascular patient samples.

We acknowledge that all complication registration systems will have some sort of underestimation. However, we believe our registration system contains several crucial aspects, such as a prospective registration twice a day on the day of the occurrence of the complication (instead of registration at the time of discharge), and a plenary evaluation of all complications once a week in an open, constructive, nonaccusing atmosphere. These aspects will limit under registration of complications and complication related costs.

CONCLUSIONS

These results suggest that complications cause a significant increase in the costs of treatment for peripheral arterial occlusive disease. Shortcomings in surgical technique and the patient's disease were the most expensive causes of complications. Surgical reoperation or alteration of additional medication, or both, or transfusion were the two most expensive consequences of complications. We firmly believe vascular surgeons should take a leading role in helping to decrease health care expenses. A principle method to decrease hospital costs includes treatment strategies aimed at prevention of shortcomings in patient management and shortcomings in surgical technique.

AUTHOR CONTRIBUTIONS

Conception and design: HC, JH, B, JW
Analysis and interpretation: HC, JH, B, JW, JF, JP
Data collection: HC
Writing the article: HC, JH, B, JW, JF, JP
Critical revision of the article: HC, JF, JP
Final approval of the article: HC, JF, JP
Statistical analysis: HC, JH
Obtained funding: Not applicable
Overall responsibility: JP

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Additional material for this article may be found online at www.jvascsurg.org.

Appendix I (online only). Classification of complications after treatment for peripheral arterial occlusive disease[21,22]

Category[a]	*Cause of the complication*[b]	*Consequence of the complication*
Cardiac	**I**—Shortcomings in patient management	**1A**—Minor complication, no long-term consequence
Pulmonary	**II**—Shortcomings in surgical technique	**1B**—Additional medication or transfusion
Renal	**IIII**—Patient's disease	**2A**—Reintervention: by surgeon
Neurology	**IVI**—Outside surgical department	**2B**— Prolonged hospital stay
(Sub)cutis		**3**—Irreversible physical damage
Hematology		**4**—Death
Vascular management		

Patient's disease: a potential life threatening complication caused by extensive pre-operative co-morbidity although all protective measurements were applied, such as: postoperative congestive heart failure in a patient with extensive cardiac co-morbidity.
Outside surgical department: complications caused by specialists other than surgical physicians, such as: pneumothorax after central venous catheter placement by the anesthesiologists.
[a]These categories were further subdivided.
[b]Explanation and definition of the causes of complications. *Shortcomings in patient management*: complications occurred because of shortcomings in the management of patient care by surgeons, residents, or interns; such as, myocardial infarction caused by shortcoming in patient management due to accidentally not prescribing proper cardioprotective medication as indicated by preoperative cardiac assessment. *Shortcomings in surgical technique*: a complication due to surgical or endovascular treatment, such as: primary bypass graft occlusion.

Appendix II (online only). Summary of the appraisal of costs, what was calculated and from were the average estimated total costs were obtained

Appraisal of costs	*Calculated items*	*Cost obtainment*
Primary treatment		
Preoperative workup		
DUSE/ECG	Laboratory, staff fee, consumable items	DTC[23] department
Diagnostic angiography	Angiography suite, staff fee, consumable items	Financial department, radiology
Hematology/microbiology	Laboratory, staff fee, consumable items	DTC[23] department; Financial department, laboratory service
Pharmacy	Medication	Pharmacy Therapeutic Guide[24]
Consulting specialists	Internal medicine, cardiology consult	DTC[23] department
Nonsurgical		
Wound management	Consumable items	Financial department, vascular ward
Endovascular or surgical procedures		
Urokinase	Medication	Pharmacy Therapeutic Guide[24]; CHC[25]
Costs of the intervention	Prosthetic materials, endovascular, vascular, nonvascular, fees (vascular surgeon, anesthesiologist, radiologist, staff)	Financial, department anesthesiology; CHC[25]
Operating room/recovery room	Sterile and non-sterile consumable items, medication, blood bank, IV fluids	Financial department, laboratory service; Pharmacy Therapeutic Guide[24]
Postoperative pain protocol	Medication	Pharmacy Therapeutic Guide[24]
After primary treatment		
Pharmacy		
Antibiotics	Medication	Pharmacy Therapeutic Guide[24]
Neurology/cardiac	Medication	Pharmacy Therapeutic Guide[24]
Hydration/dehydration	Medication	Pharmacy Therapeutic Guide[24]
Blood bank	Laboratory, staff fee, consumable items	Financial department, vascular ward
Admission		
Bandage, urine catheter	Consumable items	Financial department, vascular ward
Length of stay	ICU and vascular ward (days), staff fee, service, housing	Financial department, vascular ward
Laboratory services		
Hematology	Laboratory, staff fee, consumable items	Financial department, laboratory service
Microbiology (blood, urine, feces)	Laboratory, staff fee, consumable items	Financial department, laboratory service
Imaging		
DUSE/ECG	Laboratory, staff fee, consumable items	DTC[23] department
Diagnostic angiography, x-ray/US/CT	Laboratory, fees (radiologist, staff), consumable items	Financial department, radiology
Consulting specialists		

Appendix II (online only). Summary of the appraisal of costs, what was calculated and from were the average estimated total costs were obtained Continued.

Appraisal of costs	*Calculated items*	*Cost obtainment*
Internal medicine	Fee, internal medicine consult	DTC[23] department
Cardiology	Fee, cardiologist consult	DTC[23] department
Neurology	Fee, neurologist consult	DTC[23] department
Endovascular or surgical procedures		
Costs of the intervention	Prosthetic materials, endovascular, vascular, nonvascular, fees (vascular surgeon, anesthesiologist, radiologist, staff)	CHC[25]; financial department, anesthesiology;
Operating room/recovery room	Sterile and nonsterile consumable items, medication, blood bank, IV fluids	Financial department, laboratory service; Pharmacy Therapeutic Guide[24]
Postoperative pain protocol	Medication	Pharmacy Therapeutic Guide[24]

CT, computed tomography; *DUSE,* duplex ultrasound examination; *ECG,* electrocardiography; *DTC,* diagnosis treatment code; *CHC,* College of Healthcare Costs; *ICU,* intensive care unit; *IV,* intravenous; *US,* ultrasound.